WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 57

TAFO, GHANA.

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WEST AFRICAN COCOA RESEARCH INSTITUTE

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FIFTY-SEVENTH QUARTERLY REPORT

JANUARY-MARCH, 1960

Any results recorded in this report should not be accepted as conclusive inasmuch as the report contains interim information only. More complete results are published in W.A.C.R.I. Technical Bulletins and elsewhere.

SENIOR STAFF

Director	J. Lamb (on leave from 23/3/60)
Secretary	H.L. Pugh
Accountant	J.N.A. Hyde
Office Assistant/Librarian	D.J. Ellis (Miss)
TAFO STATION	
Division of Entomology	E. Dunn
	K.B. Armstrong (on leave from 23/3/60)
	M.R. Smith (on leave)
Division of Pathology	J.W. Blencowe
	A.L. Wharton (on leave from 9/3/60)
	A.A.F. Brunt
	P.D. Turner (on leave from 16/3/60)
	A. Attafuah (on scholarship in U.K.)
Division of Botany	D.R. Glendinning
	R.G. Hurd
	R.G. Lockard
Division of Chemistry	R.H. Kenten
	R.K. Cunningham
Division of Agronomy	T.H.R. Hall
	R.W. Smith
Statistician	C. de Jonge
Laboratory Technicians: (Electronics)	A.J.H. Arnold
(Spectrography)	J.C. Burridge
Plantation Manager	H.W.S. Allison
Maintenance Engineer	G.O. Hayward
Works Superintendent	E.K. Berko (returned from leave 18/2/60)
Guide-Demonstrator	F.E. Decker
Medical Officer	P.K.K. Knudsen
IBADAN STATION	
Deputy Director (Nigeria)	T.W. Tinsley
Entomologists	R.G. Donald (on leave)
	P.F. Entwistle (returned from leave 2/1/60)
	C.K.H. Martini
Pathologists	J.M. Thresh
	D. Kay
Agronomist	J.F. Longworth
Mycologist	E.C. Hislop
Plantations Officer	W. Rides
WEST AFRICAN FUNGICIDES RESEARCH UNIT	
Chemist	P.O. Park

STAFF MATTERS

Mr. E.K. Berko returned from leave during the quarter. Mr. P.F. Entwistle, formerly at Tafo, joined the staff at Ibadan on 2nd January, 1960 at the conclusion of his leave.

Mr. J. Lamb proceeded on leave on 23rd March 1960, and Dr. J.W. Blencowe took over as Acting Director. Messrs. K.B. Armstrong, A.L. Wharton and P.D. Turner proceeded on leave.

Dr. C.K.H. Martini spent two weeks at Rothamsted Experimental Station, working with Mr. H.L. Nixon.

VISITORS

Visitors to Tafo included four officials of the International Monetary Fund, Washington, and three officers of the Ministry of Agriculture and Natural Resources, Western Region of Nigeria.

Visitors to Ibadan included the Nigerian Federal Minister of Economic Development, Malam Shehu Hagari, Mr. C.W. Young of Rowntrees Ltd., York and Mr. A.K. Briant, Director of Agriculture, Zanzibar.

MANAGING COMMITTEE

Meetings of the Managing Committee were held at Tafo on 8th-9th January and at Ibadan on 3rd February, 1960.

Plans to build a Greenhouse for Botany Division were approved and authority given to commence work on it immediately. Approval was also given for the building of a new Central Store.

DEVELOPMENT OF PLANTATION AT GAMBARI - NIGERIA

Acquisition:

The Northern portion of the Gambari Forest Reserve was chosen from various other sites within the Ibadan Area as the most suitable for the establishment of an experimental station. In collaboration with the Forestry Division of Ministry of Agriculture and Natural Resources three blocks of land - North, South and West containing good cocoa soils were selected. The whole comprised some 770 acres of which approximately 350 acres are suitable for cocoa cultivation.

The boundaries of all blocks have been demarcated and beacons placed at changes of direction, with intermediate pillars at 20-chain intervals. Where possible forest compartment boundaries were used. Pending finalisation of a lease, the boundary traces are being kept open and only preliminary clearing is being done.

Water Supply:

There is a major problem of providing an adequate water

supply for domestic and laboratory use. Three possible sources have been investigated:

(a) The sinking of wells.
(b) The construction of a storage dam across a temporary stream.
(c) To draw water from the River Ona.

Sources (a) and (b) have proved to be unsuitable. The River Ona forms the Western boundary of the plantation and analyses of water samples show heavy contamination with faecal B. coli. Expert advice has been obtained and two firms of high repute have given assurances that adequate filtration would supply a potable supply. Proposals and estimates for a water treatment plant are undergoing examination.

Building sites etc.

Selected sites for senior staff quarters and labour lines have been cleared of low bush and approved by the architects. The Electricity Corporation of Nigeria are investigating the possibility of supplying power. Permits for the installation of a private generating plant require the approval of Electricity Corporation of Nigeria and their decision is awaited. It is proposed to run all plantation transport on Diesel power, and the first purchases have been a Land Rover and one Massey Ferguson Tractor.

AGRONOMY DIVISION

OLD STATION FARM

Table A1 : Tree Mortality - January - March, 1960

Month	Trees Destroyed		Total	No. of Seedlings Removed
	Swollen Shoot	Undiagnosed		
1960				
January	29	-	29	39
February	40	2	42	21
March	54	-	54	28
Total	123	2	125	88

SQUARE MILE

Harvesting Mature Cocoa

Routine harvesting although on a reduced scale occupied all personnel during the quarter. Yields are shown in Table A2.

Table A2: Yield in Pods of Mature Cocoa under Experiments - January - March, 1960.

Experiment	Plot No.	Healthy	Diseased	Total
U.A. Spacing and Pruning	B2	7,835	168	8,003
U.A. " Extension	B2(a)	1,892	36	1,928
U.A. Multiplication	B1	6,365	182	6,547
Amelonado Spacing Trial	J1	14,828	650	15,478
Factorial Fertilizer Trial	G5	16,953	729	17,682
2nd Establishment BI	L2	529	3	532
" " BII	H1	1,245	13	1,258
Uniformity Trial	G1	6,015	193	6,208
Amelonado Pruning Trial	P2	350	13	363
" Source Trial	G4	373	31	404
Shade and Manurial Trial	K1	3,831	43	3,874
Amazon Tree Forming & Pruning	D7	212	-	212
Pathology Expt. Plot	A4	733	5	738
" " "	H2	1,941	1	1,942
" " "	H3	4,766	8	4,774
T o t a l	-	67,868	2,075	69,943

YOUNG COCOA

Routine maintenance was carried out on the shade experiment and the virus resistance variety trial. Preparations for experiments to be planted in 1960 continued throughout the quarter.

PROPAGATION

During the quarter 1,988 cuttings of different clones were set of which 960 rooted successfully.

CLONAL NURSERY

An experiment to investigate the cutting productivity and rooting potential of various clones was started. All parent material except that still required by the Plant Breeder for pollinations was stumped. By the end of quarter 90% of the stools had thrown out shoots. Provision has been made to replan with cuttings where regeneration has failed.

FOREST TREE AND ORNAMENTAL NURSERY

A start was made on restocking the forest tree nursery. Over aged planting material was destroyed while varying numbers

of miscellaneous ornamental shrubs were supplied to members of the staff and to the new water works installation.

New planting material from Aburi Botanical Gardens was obtained. 150 Fagara melanorchachi from the Belgian Congo have been successfully established. Seed of sour and sweet orange for stocks have been sown while over 73,000 seed of Terminalia ivorensis have been sown.

DISTRIBUTION OF PLANTING MATERIAL

Pods - F3 Amazon:	
Department of Agriculture, Western Region, Nigeria	23,025
" " " Northern " "	150
University College of Ghana	113
Sales to W.A.C.R. Employees	3,750
Pods - Amelonado:	
For use by the Institute	35
Dr. R. Heiss, Western Germany	5
	27,078
Kumasi College of Technology . .	957 rooted cuttings

RAINFALL

Details of rainfall over the quarter are shown in Table A3.

Table A3: METEOROLOGY

Month	1960		Past 21-year means	
	Rainfall (ins.)	Wet Days	Rainfall (ins.)	Wet Days
January	2.95	4	1.49	3.7
February	3.28	8	3.52	6.8
March	6.84	16	6.07	11.9
Total	13.07	28	11.08	22.4

Plots Committee

The Plots Committee met twice during the Quarter mainly for the purpose of allocating land for experiments. It decided that the 'harvesting year' should commence on the 28/29th February instead of 1st April, for all experimental plots. The yield records of the Old Station were examined and it was decided to discontinue detailed crop-recording on all except a few selected plots in the Old Station.

PATHOLOGY DIVISION

VIRUS RESEARCH

Effect of virus infection on growth and yield of Amelonado and Amazon cocoa

In Experiment A4 nearly all trees graft-inoculated with the Bosomuoso, Dawa and New Juaben isolates of the swollen shoot virus and 77 per cent of those inoculated with the mottle-leaf virus (Kpeve isolate) have now shown symptoms. Forty-six per cent of trees graft-infected with the Bisa isolate have developed swellings. The canopy of many trees infected with severe isolates has continued to deteriorate (Quarterly Report No.56).

In Experiment H2 only 46 per cent of the Amazon trees graft-infected over a year ago have shown symptoms whereas 80 per cent of the Amelonado trees are visibly infected. There has been little effect of virus-infection on the canopy of the infected Amazon trees but, as in Experiment A4, that of Amelonado trees has been severely affected.

The joint W.A.C.R.I./Division of Agriculture experiments (Quarterly Report No.55) have continued satisfactorily.

Mechanical transmission of cocoa swollen shoot and mottle leaf viruses

Isolates of the cocoa swollen shoot and mottle-leaf viruses have been transmitted from infected baobab seedlings (*Adansonia digitata* L.) to cocoa half-beans and young *Adansonia digitata* seedlings by mechanical methods. Slurries made by macerating infected *Adansonia digitata* leaf tissue after vacuum-infiltration with a cold (4 - 10°C. at pH 8 or 8.5) solution containing phosphate, cysteine and usually ethylene diamine tetra-acetate have been shown to be infective. A rate of up to 12 per cent transmission has been obtained with swollen shoot and up to 4 per cent with mottle-leaf virus. Although transmission rates are low, negative results in control experiments indicate that there is little likelihood that they arose from accidental contamination.

A GALL DISEASE OF COCOA IN GHANA

Available information on this disease has been prepared for presentation at the Sixth Commonwealth Mycological Conference to be held in London in July, 1960.

STUDIES ON BLACK POD DISEASE

Resistance and tolerance

Data from the 2nd clonal trial for the 1959/60 season

is given in the table below:

Selection	Total pods per tree	Total black pods as a percentage of total pods	Selection	Total pods per tree	Total black pods as a percentage of total pods
D70	30.1	5.9	ICS7	26.2	28.2
U6	27.6	7.2	TF1	25.5	28.3
P30	28.4	10.6	W63	18.8	28.8
D71	17.8	12.0	W41	18.0	32.7
O4	21.2	12.5	E9	26.0	33.6
C22	23.9	13.9	TF2	22.1	34.7
E1	19.2	14.1	A56	26.3	40.9
S21	25.1	15.8	R15a	30.1	45.7
ICS1	25.3	23.0	R15b	18.7	59.9
B1	36.2	28.1			

A second year's set of detailed records will be taken on this trial. However, the differences in black-pod incidence between the two extremes of selection D70 and R15 are so striking that provision is now being made to incorporate progeny from crosses with these clones as parents in the resistance trial at Mpraeso. Hand pollinations will be made this year and land reserved at Mpraeso for planting the seedling progeny in 1961.

Importance of black pod disease in Ghana

Quarterly report number 56 gives the main results from a survey to estimate the importance of black pod disease in Ghana. The data was collected from five years detailed records on the Ministry of Agriculture "Capsid Yield-Recorded Units."

There appears to be no reason why the average yields from farmers' cocoa in Ghana should not be increased from a level of 200 to 250 lb. dry cocoa per acre to a conservative 500 lb. by the efficient control of capsid pests, regular harvesting and the improved management which the 'Capsid Yield-Recorded Units' have received. However, even at this level of yield the numbers of diseased pods to be expected are still probably insufficient to justify the application of fungicide sprays. The table below show the monetary value of average crop losses to be expected from one acre of cocoa in the areas surveyed, at the price paid to the farmer (£112 per ton dry cocoa) and at an estimated price received by the Ghana Cocoa Marketing Board on the world market(£250 per ton).

Value (£'s) of average crop losses due to black-pod disease, from trees yielding 500 lb. dry cocoa per acre on 11 plots in Southern Ghana and 12 in Ashanti, over

5 years.

Price per ton dry cocoa	Region		
	Southern Ghana	Ashanti	Southern Ghana and Ashanti
£112	5.3	3.7	4.4
£250	12.7	8.2	9.6

The value of these losses can be compared with the cost of £7.8 per acre for applications of 1.7 per cent. Perenox applied by power-sprayers at Tafo (Plantation Manager's records, W.A.C.R.I) These costs do not include the capital cost of a power-sprayers but in Ghana these are being purchased on a huge scale by farmers for capsid control and would be available for applying fungicides.

Thirty-two of the 45 "Capsid Yield-Recorded Units" plots are being used this year for a spraying trial against pod disease. The three treatments are: (A) Perenox applied 6 times at fortnightly intervals beginnning during the last week in April, (B) Perenox applied 10 times at three-weekly intervals beginning at the same time as (A), (C) Control plots, unsprayed. The Perenox will be applied low-volume at a concentration of 26 oz. in 10 gallons per acre. Treatments (A) and (B) are expected to cost approximately £3.5 and £6 per acre respectively, excluding the capital cost of equipment. The acreage under each treatment will be 30.0 acres (A), 29.2 (B) and 55.0 (C)

In conjuction with Dr. Blencowe a paper on the survey results has been prepared for the Sixth Commonwealth Mycological Conference.

Strains of Phytophthora palmivora

An extensive programme of crossing tests to examine the occurrence of complementary strains of P. palmivora throughout the world has been made. For the most part, the isolates fell into either the 'cacao' or 'rubber' groups of the species, but two isolates from Sierra Leone and one from Angola failed to produce oospores in any crosses. Few or no oospores were produced by complementary strains when grown together on oatmeal agar at ambient temperatures; at 60°F., however, they were produced in abundance in most cultures. Isolates from Ghana and Ivory Coast were all the 'cacao' group, which is probably predominant in Sierra Leone, and the dominant isolates in Nigeria, Southern Cameroon, Fernando Po, and Cameroun were of the 'rubber' group. Occasional isolates of the 'cacao' group were recorded from Ibadan and Umuahia in Nigeria and from Isobi in Southern Cameroon. Very infrequent crosses were found between isolates

of the 'rubber' group. Isolates of both groups were obtained from Gabon, and the single isolate from Belgian Congo was of the 'cacao' group. The unusual isolates from Sierra Leone and Angola could not be classified with absolute certainty; in many respects they resembled the 'atypical' description of the species.

Isolates from countries outside West Africa were mainly of the 'cacao' group, being found in British Guiana, Ceylon, Dominica, Jamaica, Malaya, New Guinea, Panama, St. Lucia, Surinam Trinidad and Western Samoa. 'Rubber' group isolates were recorded from Jamaica and North Borneo, but these were quite unlike isolates of the same group from West Africa. It is apparent that 'cacao' and 'rubber' strain designations are an inadequate description of the different strains of the pathogen occurring on Theobroma cacao alone.

Saprophytic survival of P. palmivora

In one soil sample spores of P. palmivora have remained viable for one year, adding further evidence to the theory that the soil acts as a reservoir of infection.

ENTOMOLOGY DIVISION

JOINT WACRI/DIVISION OF AGRICULTURE CAPSID CONTROL TRIALS

The series of trials in Ashanti begun in 1958, to compare the effectiveness against capsids of Endrin applied at 1/2 oz. per acre, Gamma-BHC at 1 oz. and Aldrin at 2 oz., that is at rates approximately proportional to their cost (see Quarterly Report; W.Afr.Cocoa Res. Inst. No.50), have now been concluded. Sufficient data have been collected to show that Endrin at the 1/2 oz. rate is significantly superior to 1 oz. of Gamma-BHC, but the difference between Gamma-BHC and 2 oz. Aldrin is not significant. It is hoped to publish the results of these trials more fully elsewhere.

JOINT WACRI/DIVISION OF AGRICULTURE:ANT/MEALYBUG CONTROL TRIALS

Method of application and formulation trials

These joint WACRI/Division of Agriculture trials which were commenced in July, 1959 with first Dieldrin application in September (Quarterly Report No.54) are giving interesting preliminary results. All treatments have reduced ant population to less than 25% of the pre-treatment figure. This has resulted in a corresponding but greater fall in the mealybug population.

Observation has been made on the plots on the incidence

of Eulophonotus myrmeleon Feld., Tragocephala spp. and another borer which has recently made its appearance following the use of dieldrin, identified as belonging to the family Metarbelidae. From pre-treatment assessment of no damage, Eulophonotus attack has developed on all the treated plots but none have been found on the control plots. As yet no other species of borers have been found.

PILOT EXPERIMENTS WITH TAGGED - ROGOR 40

A preliminary experiment to follow the uptake and translocation of Rogor 40 by cocoa has been carried out. Mature leaves of fans and chupons were painted with tagged material and assessment was made after 24 hours, 3 days, 7 days and 14 days. Five fan branches and five chupons were used for each assessment period.

Further trials with soil, leaf and bark application to seedlings have also been started.

PERSISTENCE OF INSECTICIDES

Harvests of 150 leaves from each plot were carried out after 24 hours, 3 days, 7 days and 14 days, following spraying with 1 oz. and 2 oz. Endrin, 2 oz. and 4 oz. Aldrin and 2 oz. and 4 oz. Gammalin 20, at 5 gallons/acre, (Quarterly Report No. 56). Application was also made to the same plots after 24 days to obtain a single sample of each treatment one hour after application.

Extraction of surface residues was made by washing in 62/82°C petroleum ether. The concentrate was evaporated off inside small glass vials and estimates of insecticide residue made by bio-assay using Drosophila melanogaster (Woodstock laboratory strain). Direct bio-assay with harvested leaves was made by caging capsids, Distantiella theobroma, with leaves in lamp glasses.

The results of this preliminary trial have not been finalised as yet but will be reported with the results of the chemical analysis being carried out on Endrin and Aldrin residues.

LEAF EATING LEPIDOPTERA

Routine collecting and rearing of lepidopterous larvae found on cocoa continues.

SHADE V. NO SHADE EXPERIMENT ON ESTABLISHED SEEDLING COCOA

This experiment continues.

NEMATODE STUDIES

Root knot eelworm, Meloidogyne sp. has been found on

cocoa seedlings at W.A.C.R.I. This eelworm causes small root galls and also swellings on the s tem of the plant just above the ground. Specimens have been sent to Dr. Franklin, Rothamsted for identification but she has been unable to put a name to the eelworm. Attempts are being made to infest other plants such as groundnuts and tomatoes with this eelworm to find if it is possible to identify the species more easily than on cocoa.

A survey is being made of the cocoa seedlings on W.A.C.R.I. to find the extent of eelworm infestation. A pilot experiment has been set up to examine the effect of eelworm attack on the growth of the cocoa seedlings compared with that of seedlings grown in eelworm free soil.

BOTANY DIVISION

PLANT BREEDING

Yields for the 1959-60 season have been higher than for the 1958-9 season in all the main Botany plots. The performances of some of the better selections is shown in table 1

Table B1 : Performance of some selections 1959-60

Introductions Trinidad Introductions area	Spacing 14' x 14'	Age from planting out (years)	Estimated yield dry cocoa (lbs/acre[x])[xx] Potential	Net
T60		15	2,500	1,730
T11		15	2,100	1,810
T76		15	2,100	1,410
T56		15	2,000	1,710
Clones				
1st clonal trial	10' x 10'			
A36		13	2,300	1,740
K5		13	2,000	1,500
ACU85		13	1,800	1,600
B2		13	1,800	1,500
S27		13	1,800	1,450
2nd clonal trial	8' x 8'			
D70		11½	2,160	1,990
B1		11½	2,100	1,610
R15		11½	1,990	1,250
ICS 7		11½	1,980	1,430
U 6		11½	1,850	1,720
3rd clonal trial	12' x 12'			
T12		4	510	220
T79/501		4	495	405
T60/887		4	420	330

(Table B1 contd.)

Introductions Trinidad Introductions area	Spacing 14' x 14'	Age from planting out (years)	Estimated yield dry cocoa (lbs/acre[x]) Potential[xx]	Net
Crosses				
8th Progeny trial	8' x 8'			
WAE4		8	2,700	2,000
WBE3		8	2,500	1,800
WAE5		8	2,400	2,000
WAE2		8	2,300	1,450
WAE3		8	2,000	1,650
WBE2		8	2,000	1,100
9th Progeny trial	10' x 10'			
WEB1		6	2,000	1,500
WAE11		6	2,000	1,550
WEB3		6	1,750	1,300

[x]Based on an assumed conversion rate of 40%, on fermenting and drying the wet beans.

[xx]"Potential" yield is based on the assumption that all pods harvested are useable. "Net" yields are the amounts remaining after deduction of all diseased and damaged pods. As some cocoa is recoverable from damaged pods the actual yields will be between these two values.

Samples of cocoa from a number of varieties are again being submitted to the British, American and a Swiss manufacturer for assessment of quality.

It was mentioned in Quarterly Report 51 that several experiments on seedling vigour had been undertaken in the nursery this year. Of these the main one consisted of a comparison of several crosses. As the number of crosses was large and all the required pods could not be obtained at the same time, direct comparison could not be undertaken. Each was, therefore, compared to open pollinated Amelonado as a standard. The plan was to compare 40 seedlings of each cross with ten of Amelonado; where possible the 40 seedlings were obtained from 5 pods (8 seeds from each pod). The seedlings were sown in baskets arranged in beds five baskets wide, four of the baskets containing seeds of the type under test and the fifth a seed of Amelonado. The Amelonado seed was placed in any one of the 5 baskets at random; this proved to be a mistake as the performance of seedlings in the outer rows in general was much poorer than those in the central rows, so that the performance of the 'standard' was far from uniform. Further, the performance of plants in the outer rows compared to those in the inner rows varied in different parts

of the nursery. (This was probably due to variations in exposure and drainage conditions). No correction of the data for this effect has been attempted. As a consequence of this lack of uniformity in the controls it was not thought worthwhile to attempt to calculate a standard error for growth rates.

Sowing took place from September 1958 to January 1959. In January to March 1959 the earlier sown progenies were compared with the controls. Comparisons of growth rate were made using the log of stem diameter squared times the stem height as the criterion of growth. Direct comparison of size was inappropriate as some of the crosses gave much larger seeds, and hence seedlings, than did Amelonado. All plants not required for field plantings were harvested and weighed in June. The progenies were compared to the controls on the basis of growth rate as derived from the estimated dry weights of the seed at sowing and the estimated dry weights in June, each based on arbitrary conversions from wet weights.

Using both methods of estimating growth rate, almost all crosses proved superior to Amelonado, and there was a measure of agreement, though not a close one, between the relative growth rates derived by the two techniques. Growth rates based on the stem volume estimates ranged from .84 to 1.25 relative to Amelonado as 1, and using the weight estimates from .94 to 1.88 with only one value, out of 27, below 1. The best individual result among crosses that could be compared using both methods was the cross T6 x T102 giving 1.22 on the basis of stem volumes and 1.30 on weights. T12 and T55 appear in general to be very good parents, giving progenies of average performances relative to Amelonado of (T12) 1.14 (6 crosses) on stem volumes and 1.21 (6 crosses) on weights, and (T55) 1.10 (8 crosses) on stem volumes and 1.19 (7 crosses) on weights. The very high value 1.88 mentioned above was from a cross sown in January, and the seedlings were still very small when weighed. Although there is little doubt that this cross (Pa35 x T7) is vigorous the actual value obtained may not be very reliable.

The significance of seedling growth rate to the yield potential of the varieties is still uncertain, though there are strong theoretical arguments for expecting at least some relationship. Relationships between early growth in the field and yield over the early years were discussed in quarterly report (No.55). Further to the studies already reported, a correlation of .87 has been established in the 9th PTA between the reduction in the rate of growth of a variety following commencement of bearing and the total yield up to March 1959. This appears to be an indication of a relationship between

yield and growth rate apart from the effect of growth rate on the date of commencement of bearing, and suggests that an equation could be set up "Growth Rate Before Bearing = Growth Rate While Bearing plus Yield" (with suitable constants).

To obtain information for the selection of parents for further breeding from among the Approved Amazon Types, samples of 30 pods (where possible) from each tree were taken from October to December 1959, the wet cocoa in each weighed, and the beans counted. Samples of 1 lb. of cocoa were weighed out and the beans in that sample counted, as a check on the other data.

While in some cases there is a suggestion that the size of bean is partially correlated with pod size, in general it appears that the number of beans per pod is correlated with pod size. In some cases it appeared possible that the bean size was segregating into recognisable Mendelian ratios, but extraneous influences such as the date of harvesting of the pods, the part of the tree from which they were obtained, and the conditions in which the particular tree was growing appear to have an effect such as to obscure this, and statistical verification has not been attempted. The various crosses differed in the ranges of pod weights, of bean numbers per pod, and of bean sizes. Apart from general information about the effects of each parent, detailed genetic information (whether heterozygous etc.) has not, on the whole, emerged clearly, though some indications have been obtained. The purpose of the observations, the obtaining of selection data, has been fulfiled.

Detailed studies of the data from the Series I trials, using the increase in stem diameter from year to year, are being undertaken. In general the performance of one variety relative to another is similar at most sites, (e.g. in growth from 1955 to 1956, and again from 1956 to 1957, T60 led all other varieties at four out of five trials in which it was planted), but some evidence of different responses of the varieties to different conditions is emerging.

An attempt to self-pollinate a self-incompatible clone by crossing it to another tree at the same time as selfing it appears to have been successful. The other tree used was homozygous for a dominant character detectable in the seedlings (axil spot); of 50 seedlings obtained from a pod 46 showed the 'axil spot' character and the other four, thought to be selfs, did not. A note is being forwarded for publication.

Assessments of the yield up to the end of October indicate that higher yields will be obtained this year than in previous years in both the 8th and 9th progeny trials.

In the F1 F2 F3 trial, the planting of which was

reported in quarterly report No.51, the superiority of the F1 generation is now clearly apparent. The F2 generation appears slightly superior to the F3, but this difference has not been demonstrated to be statistically significant.

In December 1959 the F1 generation had an average stem diameter of 3.22 cms, the F2 2.68 cms, and the F3 2.63 cms representing increases in diameter from planting in May 1958 of F1 2.59 cms. F2 2.15 cms, and F3 2.01 cms. Both in actual diameters and in the increases from planting the F1 is significantly better than either the F2 or F3 generations at P = 0.001.

In August 1959 the F1 generation had an average of 67.3 leaves per plant, the longest leaf on each plant averaging 40 cms in length, the F2 had 53.7 leaves per plant with the longest leaf 38.1 cms, and the F3 49.3 leaves per plant, the longest being 36.5 cms. Relative leaf areas are thus about F1 108, F2 78, and F3 66 per plant (arbitrary units derived from leaf number x leaf length^2).

These observations emphasize that it will be very important to persuade the farmers, when the F1 seed of the new hybrid varieties becomes available from the seed gardens now being planted, not to use second generation seed but to return to the Division of Agriculture for all their seed requirements.

In quarterly report No.53 it was stated that over the period November 1958 to February 1959 the F1 generation had grown less well than the others. This observation was based on seven of the sixteen blocks that had been chosen for routine analysis, however, when all sixteen blocks are considered the F1 was superior to the others. The F1 generation has in fact increased in stem diameter more than either the F2 or the F3 generation over every 3-month period from planting.

CHEMISTRY DIVISION

SOIL FERTILITY

Field Experiments:

The 1959/60 harvest, was completed on March 31st but statistical analyses of the results have not yet been completed.

The pattern of responses to the major nutrients has become clearer, definite responses to Nitrogen in combination with phosphorus, have been obtained at 5 out of 6 sites in Ashanti. All four factorial trials in the Eastern Region also indicate a response to phosphorus. In view of these results, the design of ten new trials in Ashanti has been finalised as

follows, and the first fertilizer application will take place in April 1960.

(a) 4 Sites : Rates of phosphorus - a comparison of 80 and 40 lbs. P_2O_5 per acre, with a control.

(b) 4 Sites: Residual effects of phosphorus - a comparison of an application of 80 lbs. P_2O_5 per acre every year, every alternate year, and every third year.

(c) 2 Sites: Types of phosphorus - a comparison of 80 lbs. P_2O_5 per acre, per year as triple super-phosphate, and as West African Rock Phosphate.

The yields from the shade and manurial trial at W.A.C.R.I. were lower than last season, but follow the previous pattern. A tendency for the fertilizer response on shaded plots to decrease with time, and on unshaded plots to increase with time, is beginning to emerge.

The 1959/60 yields were:-

	lb/dry cocoa per acre
Shade/No Fertilizer	756
Shade/Fertilizer	906
No Shade/No Fertilizer	2,187
No Shade/Fertilizer	3,088

Irrigation:

The pilot irrigation experiment continued with the treatments as follows:-

1. Control : No irrigation
2. 13% : Soil not permitted to dry out to less than 13% soil moisture.
3. 18% : Soil not permitted to dry out to less than 18% soil moisture.

N.B. Field Capacity = c. 25% soil moisture. Permanent wilting point = c 5% soil moisture.

One third of the Shade and Manurial trial, (a cross section through the original treatments) has been irrigated since January 1st, 1960. Water is applied, by an overhead sprinkler system using a turbo-spray line, according to the following formula, which is intended to maintain the soil at or near field capacity.

$$I = 18 - (Rc + Rp + Ip)$$

where I = Current month's irrigation need in inches.

Rc = expected current month's rainfall, in inches (calculated from 21 year mean).
Rp = Previous month's rainfall in inches.
Ip = Previous month's irrigation in inches.

The application of this formula will be reviewed at the end of the year.

Pot Experiments:

The 2^4 NPKMg nutritional experiment previously described (cf. Quarterly Reports, 54 and 55) was harvested in January, 30 weeks after planting. Chemical analyses for NPKCa and Mg were made on four sub-samples from each treatment; leaves, stems, taproots and fibrous roots. The large amount of data obtained will be presented and discussed in detail at a later date. Certain main results can, however, be recorded here. The plants responded well to the shade reduction treatment (heavy shade at planting reduced gradually to full exposure during the first 18 weeks of growth). Nitrogen gave the greatest growth response, the over all mean response being about + 50% for height and plant weight. The best treatments (NKMg and NPKMg) had a final mean height of 99 cms. compared with 70 cms. for the control plants.

A further experiment was commenced in February using the concrete tank layout. Seedlings from the nursery which had been previously transplanted into concrete pots, fertilized and fully hardened to withstand exposure to full daylight, were used in a 2^3 factorial layout to compare the following factors:-

1. Constant watering from below, as described earlier (Quarterly Report No.55), versus just sufficient watering by hand to prevent wilting.
2. Overhead shade of approximately 85% versus no shade.
3. Side protection with slatted screens versus no side protection.

Ten seedlings were grown in each of the 8 treatments and the experiment was planned to continue for about 12 weeks.

Laboratory Work:

The Soil Chemist (Mr. R.K. Cunningham) completed a programme of soils studies, particularly of nitrogen and the effects of exposure on soil, before proceeding on terminal leave in April.

Spectrographic analysis revealed that the application of ammonium sulphate to this particular soil (WACRI series)

causes a large increase in the Manganese uptake of cocoa seedlings (grown under the general conditions of the concrete-tank pot experiment layout). This effect was due to a decrease in soil pH. The iron and copper concentrations in the plants were not affected. The mean concentration of manganese in oven dried leaves from the ammonium sulphate treatments was 1,480 ppm. compared with 340 ppm. for plants which did not receive this fertilizer. Further investigation of the increase of manganese uptake resulting from the use of ammonium sulphate is planned. The mean leaf concentrations of iron and copper were 90 ppm. and 8 ppm. respectively (determined spectrographically).

COCOA PREPARATION

Studies of the fermentation of small lots of cocoa in the laboratory continue. With Amelonado cocoa, freezing and thawing the beans followed by incubation for 24 hours at 37° and air drying usually gives good quality cocoa. Occasionally the quality if poor and this may be due to lack of control during drying. Experiments will be made with controlled drying using infra-red radiation as source of heat. Work on the fermentation of large batches of cocoa by the tray method continue.

PLANTATION MANAGEMENT DIVISION

PODS HARVESTED

Table M1 below shows the number of pods harvested during the quarter:-

SQUARE MILE:

	Young Planted Cocoa	Mature cocoa	Total Pods
	Amelonado	Amelonado	Amelonado
January	4,928	3,812	8,740
February	118	751	869
March	132	665	797
Total	5,178	5,228	10,406

OLD STATION

January	2,043	4,709	6,752
February	127	110	237
March	70	1,323	1,393
Total	2,240	6,142	8,382

IBADAN STATION

PATHOLOGY SECTION

VIRUS RESEARCH

Transmission of Nigerian Cocoa Viruses

Two species of nematodes (Xiphinema sp. and Hemicyclophora sp.) are now being tested as possible vectors of cocoa necrosis virus (CNV). The known nematode transmitted viruses are sap transmissible to a wide range of host plants and attempts are being made to transmit CNV mechanically to other host plants.

Aphis gossypii Glover has transmitted the cocoa swollen shoot virus (CSSV) isolate from Ajia to five out of 100 test plants. The number of test insects used was 50. No transmissions have been obtained with other isolates of CSSV or cocoa mottle leaf virus.

Several preparations of CSSV from cocoa and Adansonia digitata L. were made by differential centrifugation and examined by Mr. H.L. Nixon with the Electron microscope at Rothamsted Experimental Station. The particles of CSSV seem to be rigid rods of approximately 220 mμ long. No particles were seen in exudates from infected leaves which suggests that the concentration of virus in its host is low.

Tolerance to Swollen Shoot Viruses

Numerous tests have been made to determine the reaction of different cocoa types to infection with swollen shoot virus. Infected stocks were not available during the quarter and the usual technique was to bud the variety under test on to healthy T(N) 38 seedlings which were later grafted with the virulent isolate from Egbeda.

The most striking feature of the results has been the extreme susceptibility of the Amelonado budlings, which rapidly showed conspicuous swellings and leaf symptoms. These were particularly severe at the initial acute stage of infection, when there was crinkling and discolouration of the young leaves which sometimes abscissed.

The most susceptible of the Trinitario clones behaved like the Amelonados, with crinkling and abscission of the leaves, severe chlorosis and swellings. However, most clones produced less severe leaf symptoms, although these were sometimes associated with large swellings. The leaf symptoms caused by the El clones, C23 and C26 were particularly mild and the swellings slow to appear. This suggests that the Trinitario

group is a potential source of tolerance and further selection may reveal outstanding clones for hybridising with tolerant Amazons.

The reaction of the different Amazon populations has been very variable and only tentative conclusions can be made from the available results. Nevertheless, all the Scavina hybrids tested produced conspicuous leaf symptoms and in some instances swellings. There was no evidence of any marked tolerance. By comparison, the Nanay x Iquitos clones usually gave inconspicuous and limited leaf symptoms, not usually associated with large swellings. There is evidence for differences in susceptibility within the Nanay and Nanay x Iquitos types and T85 (Na34 x IMC60) seedlings have proved outstandingly tolerant in two tests in which they produced only very mild or transient leaf symptoms and no swellings.

The Parinari and Parinari x Nanay clones have given quite distinct necrotic symptoms **not** reported previously in Ghana or Nigeria. These symptoms appeared first as chlorotic flecks along the third and fourth order veins which later become necrotic. In some instances the leaves hardened and remained, but usually the necrosis spread into the main veins until the leaves and petioles collapsed. The necrosis sometimes spread to the growing point and growth was then checked. The precise significance of the necrosis symptoms and the associated effects on growth and yield are being evaluated. Nevertheless, it is already clear that these symptoms are not confined to laboratory tests with young, particularly sensitive material, because at Koroboto young trees have been affected in the same way after being infected 20 months after planting.

The apparently severe effect of virus on the Parinari x Nanay clones is unfortunate because they are particularly high yielding types which have a prominent place in the W.A.C.R.I. plant breeding programme as parents of the vigorous series II hybrids. This suggests that further work will have to be done in selecting equally good Amazon parents which can be combined with Amelonados or Trinitarios to give acceptable hybrids with a high degree of tolerance to virus. It is hoped to co-operate with Mr. Glendinning at Tafo and produce such crosses during the coming season so that populations can be tested at the earliest opportunity.

BLACK POD CONTROL

Laboratory Studies

The laboratory sprayer used in the fungicide assessment technique described in the Annual Report 1958-59 has been

simplified and rebuilt.

An attempt has been made to examine the toxicity of three copper compounds by the slide germination technique, using the settling tower described in a previous report as a means of applying the compounds to the glass slides. Zoospores of Phytophthora palmivora, obtained from artificial cultures on cassava dextrose agar were used as the test organism. The results of these tests were unsatisfactory for the following reasons. The zoospores are very sensitive to copper as might be expected from their small size and the range of fungicide concentrations over which inhibition between 0 and 100% occurs is small. Errors in the application of the fungicides to the slides in the settling tower, although small by usual standards, were too large for these tests. The slide germination test was therefore abandoned in favour of the test tube dilution technique for use with a slide germination technique (Amer. Phytopath. Soc. 1947). This technique was modified in an attempt to make it more precise. The copper compounds investigated were suspended in a given quantity of water and placed in sedimentation chambers. After 48 hours samples were withdrawn from a predetermined level and divided into two portions. One portion was analysed chemically and the other was used for the germination inhibition tests after appropriate dilution. The results of these tests were reproducible and showed that the toxicity of the copper ion from cuprous oxide and copper oxychlorides to zoospores of P. palmivora was very nearly the same.

This result is at variance with the apparent failure of copper oxychloride, as compared with cuprous oxide, in preventing the infection of cocoa pods by P. palmivora in the laboratory studies reported in the previous quarterly report.

References:

Burchfield, H.P. and Goenaga A., (1957)
Equipment for producing simulated rain for measuring the tenacity of spray deposits to foliage. Contr. Boyce Thoms. Inst. 19, 2, 133

American Phytopathological Society, Committee on standardisation of fungicidal tests (1947). The test tube dilution technique for use with the slide germination method of evaluating protectant fugicides. Phytopath. 37, 354

STUDIES ON THE "DIE-BACK" OF COCOA

The perfect i.e. perithecial stage of the die-back fungus

Calonectria rigidiuscula (Berk & Br.) Sacc., and the imperfect stage of this fungus Fusarium decemcellulare (Brick) have been produced in culture and the identifications confirmed at the Commonwealth Mycological Institute, Kew. When aqueous suspensions of micro and macro-spores were inoculated into the stem there was a rapid spread of the fungus in the host, but no spread was observed with aqueous suspension of ascospores.

Studies have been continued on the spread of die-back in twigs of virus-free and virus-infected trees, that have been inoculated with C. rigidiuscula. At Tafo, Ghana, measurements were made on twigs on 18 trees free of virus and on 18 naturally infected with virus. After six months exposure it was found that die-back had spread, linearly, a total of 3,558 inches, totalling 606 cu. inches on the virus infected trees, compared with a spread of 2,343 linear inches, totalling 266 cu. inches, on the virus free trees. In another experiment the amount of spread was found to vary with the strain of virus introduced into the trees.

The amount of spread of "die-back" on twigs, with and without virus infection

Strain of Virus infection in the tree	Total amount of spread recorded over a period of 6 months on 4 trees for each virus infection.	
	Linear spread in inches	Cubic spread in inches
Severe New Juaben	969	180.7
Kpeve	529	134.9
Bisa	548.5	87.6
Mild New Juaben	307.5	32.2
No Virus	84	5.7

In Nigeria over a period of one year the number of twigs which died back and the amount of spread of die-back has been recorded on twigs inoculated with C. rigidiuscula. A series of twigs were inoculated each month. The number of die-back was recorded during the following 2 months and the amount of spread recorded over a period of six months. There was a distinct seasonal variation in the number of twigs to die-back, but this did not appear to be directly related to rainfall.

It is suggested that the twigs were less vigorous following a period of drought and not able to combat C. rigidiuscula inoculations, and the same applied after a period of heavy rainfall and low temperature when little new growth took place. In another experiment it was shown that after inoculation with C. rigidiuscula, green/brown twigs bearing numerous leaves did not die back as frequently as dark-brown twigs with only a few leaves. It is believed that percentage of twigs to die-back after inoculation is related to their vigour. Further information on this problem is anticipated from the die-back experiments being conducted on different varieties of cocoa.

AGRONOMY SECTION

AGODI COCOA EXPERIMENTAL FARM

Nursery Trial

A second trial was laid down in October. Three levels of shade were used :-

(a) Heavy shade;
(b) Light shade, which was reduced to no shade by March;
(c) No shade.

Under each shade treatment there are three watering regimes:-

Watering on alternate days (W1)
Watering twice each week (W2)
Watering once each week (W3)

There are close packed, and wide spaced seedlings in each of these treatments. Early growth in the shade treatments was similar to that in the previous experiment (Quarterly Report No.54), but seedlings under light shade with frequent watering have made prolific growth and it is likely that at planting time in May they will be unsuitably large, as the tap root will be damaged when moving the pots. However, it is possible that even in this treatment growth is limited to some extent by the water supply and more vigorous seedlings could be obtained with more frequent watering.

These two trials have shown that with suitable adjustment of shade and water supply, extremely vigorous seedlings can be produced, and in the present trial planted earlier in the main-crop period the seedlings under light shade may become unwieldly. It is possible therefore that the management adopted in the nursery will be determined by the time of planting of seed, and must be directed towards producing the most vigorous and the most managable seedlings by planting time.

ALAKIA SEEDLING EXPERIMENT

This trial, planted in June, is intended, like the Koroboto experiments, to evaluate the effect of virus on young cocoa in the field, under different cultural conditions. The experimental layout is a 2^2 factorial involving fertilizer applications, and virus inoculations superimposed upon main plots which consist of four different ground covers. Fertilizer was applied in September and March, and virus inoculations were made in March. The plot was not shaded until November, when a palm frond canopy was erected.

After planting, both Amazon and the Amelonado - Trinitario hybrids shed leaves, and there was an interesting difference in the rate of recovery from this planting shock. Leaf production in the F3 Amazon seedlings soon exceeded leaf fall, and an overall increase in number of leaves was noted. By comparison the Amelonado type seedlings continued to lose more leaves than were produced, so that there was an overall reduction in number of leaves. This difference is confounded with replicates and so a precise statistical comparison cannot be made.

The leaf number data have proved to be a particularly sensitive measure of quite small treatment differences. For example, immediately after fertilizer applications in September, leaf fall in the manured plots was significantly greater ($P = 0.05$ degrees of freedom for error = 15) than that in control plots. This difference disappeared in the leaf count in the following month, and by November the situation was reversed, and the manured plots had produced significantly more leaves ($P = 0.05$). In subsequent months this effect did not attain significance.

There was a significant fertilizer - groundcover treatment interaction ($P = 0.05$) after application, more leave being lost in the grass plots receiving fertilizer. Later, this effect was not noted, but analyses of height data in November showed a significant interaction between fertilizer and treatments ($P = 0.01$), and manured plots under grass had made greatest growth. These effects did not appear in later records, and were presumably masked by the changes in the effect of the ground cover treatments with season, which are described below.

After June seedlings in plots planted with grass (Panicum maximum) and plots in which natural regeneration of weeds was allowed, lost significantly less leaves than the mulch and bare soil treatments ($P = 0.05$ degrees of freedom for error= 12). Presumably in exposed conditions some lateral protection was afforded by the former treatments. By December, increase in

leaf number was greatest in mulched and bare soil plots (P = 0.001), possibly a measure of great competition for moisture in the plots with a cover of vegetation in dry season conditions. Covariance analysis of girth data in February confirmed that growth in mulch and bare soil plots was significantly greater than in the grass and weed treatments. Appropriate sub-plots were infected with virus in March and the effect of virus infection on growth under this range of conditions will be studied.

ENTOMOLOGY SECTION

SHOT HOLE BORER STUDIES

Alakia I.

Previous experience has indicated the inadequacy of normal insecticidal techniques in the control of shot hole borer (Xyleborus morstatti Hag.) of cocoa. (Quarterly Reports 52 & 53). An experiment (see Agronomy section) laid down at Alakia I, to study the effects of four cultural treatments on virus and non-virus infected seedlings, also provided an opportunity to investigate the incidence of shot hole borer under a variety of conditions. At the time that shot hole borer counts were made (January, February and March, 1960) virus had not been introduced into the plants.

Statistical analysis of the data collected at the end of January indicated that significantly less (P = .005) plants were attacked in the bare soil and mulched plots (C & D) than in those with a growing cover (A & B).

The borer counts were in February and March more similar to those of January. At no time did a difference in susceptibility to attack emerge between Amazon and Amelonado plants.

Koroboto II.

Counts were made on this plot (planted in June, 1958) in January, 1959, to observe the effects of several factors (shade and no shade, severe virus, mild virus and no virus, Calonectria and no Calonectria) and their interactions, on shot hole borer incidence. Whilst no clear correlations emerged between borer incidence and any of the treatments, the percentage of plants attacked was quite high (32.2).

Counts made just a year later, in February, 1960, whilst still showing no correlation with any of the factors imposed on the plants, were much lower (4.5 per cent) than in the previous year. This tends to bear out the idea that, except in the most marginal of cocoa growing areas, shot hole borer is only a major pest in the first year after planting. This is quite unlike the position with coffee, where X. morstatti causes continual

trouble throughout the life of the tree, though generally on first and second year wood only.

MINOR PESTS OF COCOA

Tragocephala Studies

Tragocephala nobilis F. var. gorilla Thoms. is the predominant species in Nigeria though at least one other, tentatively identified as T. Mniszechi Thoms. var elongata Jord., is known to occur in Ibadan Province.

Field observations during the quarter have shown that Tragocephala was present only in the larval stage in January, that pupation was beginning towards the end of February and that the first adults were emerging early in March. Ring barked chupons containing eggs were found on the 22nd of March and taking into account the incubation period, it is estimated that the first eggs were laid at the end of the first week in March. However, this seems to be only the beginning of what will prove to be an extended period of adult emergence and activity.

Aprostocetus sp. nr. diplosidis Crawf. (Hymenoptera, Eulophidae), already recorded from Ghana on T. nobilis var. castinia Thoms. and from the Belgian Congo on either T. nobilis var. maynei Gah. or T. Guerini White, was also found in Nigeria, probably on T. nobilis var. gorilla, and was a common cause of egg mortality: from 2 to 16 adults have been bred from single eggs.

Billaeae vanemdeni Fennah (Diptera, Tachinidae), a common parasite of T. nobilis var. castnia in Ghana, has not yet been found in Nigeria.

Hypothenemus pusillus Egg. (Coleoptera, Scolytidae) also causes some egg mortality as it attacks the dying twigs above the point of ring barking, utilising the oviposition slit as a means of easy entry and invariably damaging the egg in the process.

Lepidopterous Defoliators

Noctuidae: during the dry season months of January and February the principal lepidopterous defoliators in the Ibadan region have been Earias biplaga Wlk. and Lophocrama phoenicochlora Hmps., but with the beginning of the rains in March, larvae of Anomis leona Schaus. have appeared in large numbers on both seedlings and mature cocoa to an extent never observed by the writer in Ghana.

Psychidae: two species have been tentatively identified as Oikticoides sierricola White and Clania cervina Drc. Both are leaf feeders and have a wide host plant range. On cocoa O. sierricola appears to pupate during the dry season: eggs have been found in February and again in March. The larviform female

lays up to 700 eggs in her own pupal case and, on emergence, the young lavae rapidly construct a silk case covered with very fine particles of leaf epidermis. At a later stage this case is covered with cut pieces of leaf, the size of which is increased with the age of the larva.

Adult males of C. cervina have been obtained in March but the peak period of adult emergence is expected to occur later than this. Adult females have not yet been observed. The laval case is covered with longitudinally arranged lengths of stick. Where cocoa is the host plant these are very often leaf petioles which the larva cuts specifically for this purpose, discarding the lamella of the leaf. The leaf is first severed at its base and allowed to fall to the earth; the larva then finds the fallen leaf, cuts off the petiole and carries it back to the host plant before incorporating it in its case.

The unetermined tachinid parasite has been frequently observed on C. cervina. The eggs of the parasite are attached to the thoracic segments of the host larva. Up to five eggs which, judging from the different degrees of development of the resulting parasite larvae, are laid at different times, have been observed on a single host.

A tachinid pupa, similar to that produced by the above parasite has been found in the empty larval case of O. sierricola, as have also the remains of a host larva destroyed by chalcid parasites.

Spider Mite

Specimens sent to the Commonwealth Institute of Entomology have been identified as an apparently undescribed species of Tetranychus (Tetranychidae).

In Nigeria spider mite seems to be principally troublesome in cocoa nurseries where it mainly infests the undersurface on leaves, though it may also affect the upper surfaces and the unhardened apical regions of the stem.

Apart from the presence of the mites themselves in their irregular reticulum of web, the first signs of attack are pale yellow areas between the veins of the leaf which later spread and eventually became necrotic. Severe attacks may lead to complete death of the leaf.